Haul-Out Preference in Harbor Seals (Phoca vitulina) at the New York Aquarium

Payden Hubbert
Former Provisional Supervisor Marine Mammals and Birds Department
Wildlife Conservation Society
New York, NY

INTRODUCTION

Harbor seals *(Phoca vitulina)* are the most widely distributed pinniped species in the world and can be found anywhere from the Arctic and Canada to more temperate locations, including the Carolinas on the east coast and southern California on the west coast (Blanchet et al., 2021). Prior to the MMPA in 1972, hunting and pollution limited the harbor seal's home range to the northern waters of Canada (Blanchet et al., 2021). However, after the Marine Mammal Protection Act was passed, the harbor seal population continued to expand with most populations of seals having successfully stabilized and returned to their historical range, resulting in a population yet to be determined on a global scale (Blanchet et al., 2021; Roman et al., 2013). Their recovery has happened despite an ever-changing seascape where food sources have been depleted, shorelines have become urbanized, and disease has spread (Johnston et al., 2018).

Seals are semi-aquatic species, which means they spend part of their lives on land and part in the water (National Oceanic and Atmospheric Administration Fisheries, 2023). While seals forage for prey in coastal waters, they leave the water routinely to rest, molt, mate, give birth, nurse, thermoregulate and avoid predation, a behavior referred to as hauling-out (Harvey et al., 2022; London et al., 2012). In the wild, seals haul-out on beaches, sandbars, reefs, rocky shores, piers and ice floes (Barefield, 2012). Ideal haul-out sites protect seals from predators, provide them with a close prey source, shelter seals from environmental elements such as wind and waves and give them access to deep water for escape if they are threatened (Barefield, 2012). Haul-out behavior increases in the summer months, coinciding with pupping, nursing and molting periods (Hamilton et al., 2014). During most of the year, harbor seals haul-out for an average of seven hours per day but increase to 12 hours per day during the molting season, when they shed their old fur for a new coat (Barefield, 2012). In addition to seasonal variations, the air temperature, air pressure, lunar patterns, tide, weather conditions and the age and sex of a seal can all factor into the time spent hauled-out (Hamilton et al., 2014).

A growing use of the marine environment for commercial (i.e. fisheries, transport and marine constructions) and recreational purposes leads to seals and humans coming into contact more frequently, often resulting in adverse effects on the species and their habitats (Andersen, 2011). To protect seals from human harassment, designating preserved areas is one of the most common forms of conservation to reduce human interaction with the species (Konrad and Levine, 2021). Protected from the public, these beaches allow adult seals to conserve energy and minimizes disruptions for nursing pups (Allbrook and Lopez, 2012) and provide space for juveniles to haul-out safely when fatigued after hunting, leaving them less vulnerable to prey (Jansen et al., 2014). However, with more humans congesting beaches, especially in large tourist and urban areas, protected beaches alone may not be a practical or beneficial solution for the species because of the space's high demand (Konrad and Levine, 2021).

Members of the public have a wide range of opinions about seal populations on beaches. The public may perceive the incoming and thriving seal populations as a species success story and alongside conservation organizations, capitalize on the opportunity to provide education

and ecotourism. On the other hand, beaches with seals may be seen as potential hunting grounds for white sharks, polluted with seal feces, or not practical for fishing with the possibility of seals consuming fishermen's catch (Lippsett, 2013). A combination of the above issues with the addition of off-limits beach areas to protect haul-outs, could cause beachgoers to view seals as a nuisance species. The possibility of human-seal conflict will likely spread as seal populations increase and has already been observed, most notably on Cape Cod, Massachusetts and La Jolla, California (Bratton 2023; Konrad and Levine, 2021)

Researching alternative methods of conservation on public beaches as protective measures for seals is important to determine what forms of conservation could reduce human and wildlife conflict. One potential solution to the aforementioned issues is implementing human-made docks for seals as additional haul-out options, away from crowded beaches. In the wild, it is common for seals to use man-made structures as haul-outs. In addition, only one known "seal dock" has been created specifically as a seal haul-out for wild populations. Located in Almada Point, California the "seal dock" was created before a ferry maintenance and operations center replaced an older dock serving as a major haul-out sight for seals (Jordan, 2017). Under the direction of Dr. James Harvey, Director of Moss Marine Laboratory, the replacement "seal dock" was positioned next to the seal's original haul-out before demolition occurred (Jordan, 2017). Observations informally concluded that seals utilized the new haul-out successfully, instead of abandoning the location, but only after the old haul-out was demolished (Bangert, 2017; Jordan, 2017).

To expand on this idea, research at the New York Aquarium aims to provide data that will build upon behavioral flexibility observed with wild seal

Harbor seal at the New York Aquarium. Photo by S. Rshaed

populations in Almada Point, California. Behavioral flexibility is defined by Lea et al. (2020) as "a quality or trait that frees an animal from the constraints of instinct and allows it to adapt efficiently to variation in the environment." In an effort to expand on this research premise, observations were conducted on the resident harbor seals at the New York Aquarium to determine behavioral flexibility. Understanding if seals will choose to utilize a human-made haul-out in addition to their existing exhibit rockwork haul-out space when presented with the choice tests the behavioral flexibility of seals in a controlled setting. New York Aquarium research explores beyond the Almada Point wild population where no alternative haul-out space was available and the only option was to adapt to the new haul-out or leave the area entirely. Based on the wild population behavior, it is hypothesized that seals will investigate the novel man-made float and a lesser portion of the population will utilize it as a primary haul-out since the exhibit rockwork is highly established and a larger haul-out for the population.

METHODS

RESEARCH SETTING AND PARTICIPANTS

The New York Aquarium's Harbor Seal exhibit consists of one 11-foot-deep pool that shares a water system with

House Name:	Sex	Subspecies	Date of Birth	Wild/ Captive Born	Birth Location
William	Male	Pacific	5/8/2009	Born in Captivity	SeaWorld San Diego
Coral	Female	Atlantic	6/15/2007	Born in Captivity	Long Island Aquarium
Kordelia	Female	Pacific	6/8/2011	Born in Captivity	Alaska Sea Life Center
Sydney	Female	Pacific	2/11/2020	Born in Wild	California
Murphy	Female	Atlantic	5/19/2020	Born in Captivity	New York Aquarium
Luna	Female	Pacific	6/14/2021	Born in Captivity	New York Aquarium
Conway	Female	Atlantic/Pacific	6/21/2022	Born in Captivity	New York Aquarium

Table B1: Name, Sex, Subspecies, Date of Birth, Captive/ Wild Birth Status and Birth Location for seven seals living in the New York Aquarium Harbor Seal exhibit.

the sea lion exhibit and is separated by fabricated exhibit rock work. The exhibit is 158 square meters, including fabricated rock work, and holds a volume of 500,000 liters of water.

Seven resident harbor seals (1.6.0) at the New York Aquarium were the focus of this study (Table B1). The population includes both Atlantic and Pacific harbor seal subspecies (two Atlantic harbor seals, four Pacific harbor seals and one half-Atlantic, half-Pacific harbor seal). The ages range from 0-14 years with three weaned pups, one juvenile, and three adults. Three seals were born at the New York Aquarium, three seals were born at other facilities and moved to the aquarium as adults, and one seal was wild caught and moved to the aquarium as a juvenile. All seals are currently in the Wildlife Conservation Society collection. It should be noted that the birth of 0.1.0 seal occurred on June 21, 2022. During this time no observations took place because the dam and pup were excluded from the study site. For this research, the first data set includes six seals while the second dataset includes seven seals.

ADDITIONS TO THE ENVIRONMENT

One 9'1" x 4'0" x 0'.10" dock structure was installed at the New York Aquarium's Harbor Seal exhibit on July 6, 2022 (Figure 1 and Figure 2). The structure is free standing away from exhibit rock work. Rated to hold 1,488 lbs, the dock is composed of animal-safe, hand-welded High-Density Polyethylene (HDPE) sheet plastic (Safety Data Sheet chemical name: 1-Butene, polymer with ethene) and completely encapsulated expanded polystyrene (EPS) foam. All plastic material meets the requirements of ASTM D4976– PE 235 & FDA 21CFR 177.1520. The structure is elevated 10" from the waterline. One side of the structure has a 3'.1" x 4'.0" ramp angled at 15 degrees for easy seal access to and from the water. The underside has a marine grade aluminum frame surrounding the entire perimeter that is 2" x 2" x 0.125" square tubing with radius corners made of 6061-T6 series aluminum. Each aluminum frame is attached to the float section with 5/16" x 2-3/4" 304 series stainless steel carriage bolts. Anchor chain brackets encased in tubing are attached to the frame in four corners of the float. Four 25 pound weights angled outwards to the floor of the exhibit are attached at each corner for stability. The New York Aquarium's Animal Curator William Hana; Moey Inc. exhibit designer, Molly Orlovich; and the New York Aquarium's Director of Facilities, Tim Macy, provided the recommended materials for the float. Sizing and design were recommended by Dr. James Harvey (personal communication, December 17, 2021) Director of Moss Landing Marine Laboratories, and mimics the design of the dock implemented in Almada Point, California.

Three all-weather trail cameras (Meidase S3 Pro Trail Camera 32mp 1296p Game Cameras with Advanced Night Vision Fast 0.1s Motion Activated Waterproof), unreachable to all animals, were installed on April 5, 2022, to take one picture every minute over the course of a 24-hour cycle (Figure 3). Cameras were equipped with infrared technology and could

Figure 1: Top view of float structure for New York Aquarium Harbor Seal exhibit. Hubbert, J., 2022.

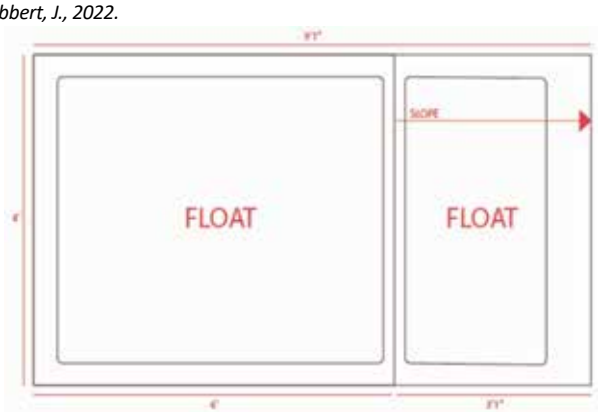


Figure 2: Side view of float structure for New York Aquarium Harbor Seal exhibit. Hubbert, J., 2022

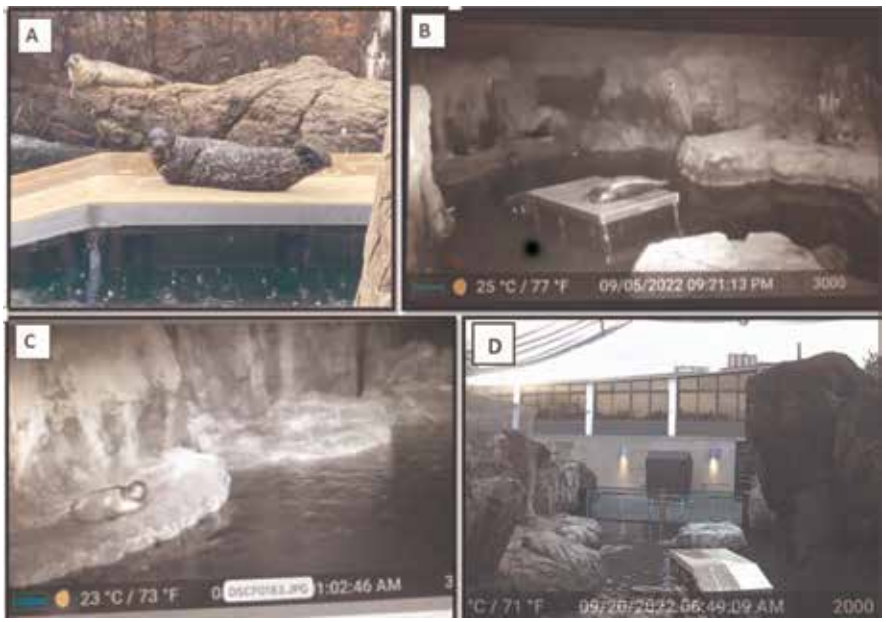


Figure 3: A- Harbor seal Murphy resting on the float in the Harbor Seal exhibit. B- Trail Camera 1 view (infrared night vision). C- Trail Camera 2 view (infrared night vision). D- Trail Camera 3 view (daytime vision).

take clear pictures regardless of most weather conditions or time of day. In addition, cameras provided the date, time, and air temperature.

METHODS AND PROCEDURE OF DATA COLLECTION

Observations occurred between April and October. The first set of observations were used as a baseline to determine the initial haul-out location preferences of the total population before the float was installed. A total of four haul-out locations on exhibit existed during the first dataset (Figure A2). The first trial included a total of 27, 24-hour observations that occurred over the course of 39 days between April 4, 2022, and May 22, 2022.

Following this, the installation of the novel float occurred on July 6, 2022. Observations resumed 30 days after installation to allow the harbor seals time to habituate to the new structures. The second set of observations began August 6, 2022, and concluded October 3, 2022. These observations included 45, 24-hour observations over the course of 55 days. The number of minutes of haul-out time on the exhibit and haul-out time on the float, along with the number of animals that used each space was recorded, in addition to the date, air temperature, water temperature, and weather conditions. By comparing where the seals hauled-out before and after the float was installed, changes in behavior were able to be observed.

Float set-up was inspected and approved by animal care management and veterinary staff prior to the first deployment to ensure animal health and safety. In addition, vertebrate research was also approved by Wildlife Conservation Society's Institutional Animal Care and Use Committee (IACUC); tracking number 22:02. The float did not conflict with areas trainers used during training sessions. The harbor seal population began investigating the float within minutes after installment.

RESULTS

A total of 72, 24-hour cycles were recorded between April 4 and October 2 correlating with the time of year beaches experience the most crowds (Dwight, R., 2007). Due to technical issues, weather conditions blowing over or washing out camera footage, and guests tipping over cameras, 24 of the 24-hour cycles (34560 minutes) were deemed accurate enough for inclusion in the study. The number of seals and amount of time they hauled-out was calculated for each night. Additionally, in order to determine statistical significance for the amount of time in which the entire population hauled-out, a separate category of "seal minutes" was calculated. In order to obtain this value, the amount of time spent hauled-out multiplied by the number of seals hauled-out was determined. If one seal was hauled-out for three minutes it would be three seal minutes, if two seals were hauled-out for three minutes it would be calculated as six seal minutes, if three seals were hauled out for three minutes it would be calculated as nine seal minutes, and so forth.

After review, less than 0.008% of haul-out time occurred between 09:01 and 15:59 (eight minutes out of 10080 minutes). For this reason, data between the hours of 09:01 and 15:59 were not analyzed, as it did not contribute to the findings. A total of 24480 minutes between the hours of 16:00 and 09:00 were analyzed.

Dataset 1	1 seal	2 seals	3 seals	4 seals	5 seals	6 seals	Total Haul-Out Mins. per Night	Total Seal Mins.
Night 1	30	17	75	34	472	0	628	2785
Night 2	16	0	0	0	0	0	16	16
Night 3	17	7	34	403	1	0	4 62	1746
Night 4	15	225	97	29	0	0	366	872
Night 5	10	37	90	373	13	0	523	1911
Night 6	13	57	220	0	0	0	290	787
Night 7	14	32	251	26	0	0	323	935
Total Haul-Out Mins. per Number of Seals	115	375	767	865	486	0	2608	9052

Table 1: Dataset One (Before Float)- Haul-out time per night vs. haul-out time per number of seals and total seal minutes at the New York Aquarium. Haul-out time calculated in minutes, 16:00-9:00, 1020 minutes per night.

Control data displayed baseline haul-out behavior of the resident seal population. These data were not used for comparison. At the time there were six harbor seals on exhibit. The number of seals hauled-out over the duration of time was noted. Seven days were analyzed over a 48-day period between April 4 and May 22 for a total time of 7140 minutes. The number of seals hauled-out over the duration of time was noted. Over the first dataset haul-out time included 115 minutes one seal, 375 minutes two seals, 767 minutes three seals, 865 minutes four seals, 486 minutes five seals and 0 minutes six seals. This calculated to 9052 seal minutes of haul-out time in total (Table 1).

The second dataset, taken 30 days after the float was installed, displayed change in haul-out location for the resident seal population. The second dataset compared the time hauled-out on exhibit compared to the time hauled-out on float. During this observation period there were a total of seven harbor seals on exhibit, after the birth of one seal. Seventeen days were analyzed over a 57-day period between August 6 and October 2 for a total time of 17340 minutes. The number of seals hauled-out over the duration of time and the location (exhibit vs. float) was noted. Haul-out time on exhibit vs. haul-out time on the float was compared in the second dataset (Table 2 and Table 3). Results show one seal hauled-out 1560 minutes on exhibit compared to 5411 minutes on the float, two seals hauled-out 1593 minutes on exhibit compared to 2850 minutes on the float, three seals hauled-out 1056 minutes on exhibit compared to 22 minutes on the float, four seals hauled-out 1200 minutes on exhibit compared to 0 minutes on the float, five seals hauled-out 1926 minutes on exhibit compared to 0 minutes on the float, six seals hauled-out 70 minutes on exhibit compared to 0 minutes on the float and seven seals never all hauled-out on exhibit or the float. Over the course of the dataset 7405 minutes were spent hauled out for 43% of the time on exhibit and 8283 minutes were spent hauled-out for 48% of the time seals on the float in total (Table 4).

Analysis to understand if there was a statistically significant difference between the two datasets was done comparing the total amount of seal minutes. Calculated into seal minutes, a total of 22764 seal minutes were spent hauled-out on exhibit (Table 2) vs. 11177 seal minutes spent hauled-out on the float (Table 3). Seal minutes were greater for the exhibit 12 of the 17 nights. A sample t-test on the 17 values was used to evaluate if there was significant evidence of preference for exhibit or float. The seals spent significantly more seal minutes on the exhibit than the float (22758 vs. 11177) with a mean difference of 482 seal minutes ($p = 0.012$).

Exhibit vs. Float	Total Mins.	% of Time
Dataset 2- Exhibit	7405	43%
Dataset 2- Float	8283	48%

Table 4: Actual time (in minutes) and percentage of time spent hauled-out classified by location and data set at the New York Aquarium.

Dataset 2: Exhibit	1 seal	2 seals	3 seals	4 seals	5 seals	6 seals	7 seals	Total Haul-Out Mins. Per Night	Total Seal Mins.
Night 1	9	23	95	55	286	11	0	479	2056
Night 2	29	63	51	106	524	0	0	773	3352
Night 3	429	111	0	0	0	0	0	540	651
Night 4	68	56	497	50	1	0	0	672	1876
Night 5	226	149	33	49	57	1	0	515	1110
Night 6	31	20	18	47	425	0	0	541	2438
Night 7	83	2	0	0	0	0	0	85	87
Night 8	4	20	162	402	33	2	0	623	2315
Night 9	76	340	3	26	0	0	0	445	869
Night 10	115	3	0	0	0	0	0	118	121
Night 11	39	70	20	2	462	0	0	593	2557
Night 12	92	379	20	0	0	0	0	491	910
Night 13	48	18	17	431	35	0	0	549	2034
Night 14	84	8	0	0	0	0	0	92	100
Night 15	133	281	107	1	0	0	0	522	1020
Night 16	60	49	33	31	103	56	0	332	1232
Night 17	34	1	0	0	0	0	0	35	36
Total Haul-Out Mins. per Number of Seals	1560	1593	1056	1200	1926	70	0	7405	22764

Table 2: Dataset 2 (After Float)- Haul-out time per night vs. haul-out time per number of seals and total seal minutes at the New York Aquarium. Haul-out time calculated in minutes, 16:00-9:00, 1020 minutes per night. Time in minutes vs. number of seals hauled-out on exhibit at the New York Aquarium.

DISCUSSION

The study's results demonstrate that captive harbor seals will utilize a novel haul-out structure, indicating that the species employs behavioral flexibility when presented with changes in their environment. The second observational period occurring between August 6 and October 2 presents the amount of time seals hauled-out on exhibit rock work compared to the float. The float, as well as the rock work, was utilized 100% of the nights by a proportion of the population. Additionally, seals hauled-out on the float for a longer period of time than the exhibit rock work. However, the amount of seals that hauled-out was significantly less on the float compared to the exhibit, as seen when time was calculated into seal minutes. Results from these data are analyzed.

Behavioral flexibility is observed in some species over others for a wide variety of reasons. Foraging strategies within most seal species are flexible and the use of various hunting techniques, with individuals switching behaviors when targeting different prey, makes these marine carnivores successful predators (Kienle, 2019). In addition, seals have several feeding strategies dependent on the behavior and species of prey being hunted (Kienle, 2019). Coping style will also play a part in behavioral flexibility of a species. Species less susceptible to stress and higher on the food chain typically have established routines, which makes them less behaviorally flexible overall (Zidar et al., 2019). Alternatively, stressed and fearful species, lower on the food chain, typically are more behaviorally flexible (Zidar et al., 2019). Seals which are found in the middle of the food

Dataset #2: Float	1 seal	2 seals	3 seals	4 seals	5 seals	6 seals	7 seals	Total Haul-Out Mins. Per Night	Total Seal Mins.
Night 1	245	2	0	0	0	0	0	247	249
Night 2	594	0	0	0	0	0	0	594	594
Night 3	576	0	0	0	0	0	0	576	576
Night 4	372	53	0	0	0	0	0	425	478
Night 5	294	1	0	0	0	0	0	295	296
Night 6	599	0	0	0	0	0	0	599	599
Night 7	169	0	0	0	0	0	0	169	169
Night 8	143	478	0	0	0	0	0	621	1099
Night 9	122	328	0	0	0	0	0	450	778
Night 10	449	1	0	0	0	0	0	450	451
Night 11	119	467	0	0	0	0	0	586	1053
Night 12	439	1	0	0	0	0	0	440	441
Night 13	151	438	0	0	0	0	0	589	1027
Night 14	527	2	0	0	0	0	0	529	531
Night 15	418	0	0	0	0	0	0	418	418
Night 16	108	534	22	0	0	0	0	664	1242
Night 17	86	545	0	0	0	0	0	631	1176
Total Haul-Out Mins. per Number of Seals	5411	2850	22	0	0	0	0	8283	11177

Table 3: Dataset 2 (After Float)-Haul-out time per night vs. haul-out time per number of seals and total seal minutes at the New York Aquarium. Haul-out time calculated in minutes, 16:00-9:00, 1020 minutes per night. Time in minutes vs. number of seals hauled-out on float at the New York Aquarium.

chain and susceptible to stress as a prey species would be categorized as the latter in these two categories (Zidar et al., 2019). It is possible that this could contribute to why seals utilized the float starting on day one of its installment (before formal data were taken) and 100% of the nights.

In addition to the behavioral flexibility of seals there could be alternative reasons for significant float use. The float may have been utilized for longer periods of time over the rock work because it was novel environmental enrichment that naturally engaged the resident seal population when first implemented. Captive seals that routinely receive novel environmental enrichment may be more inclined to explore and utilize a novel float over wild seals. This could be why the wild seals at Almada Point did not use the novel "seal dock" until their previous dock was demolished (Jordan, 2017). Environmental enrichment is defined by Meade et al. (2014) as "a resource that promotes psychological well-being by either facilitating species-typical behavior or eliminating abnormal behavior". These items provide animals in a zoological setting with new challenges that they must overcome (Banton-Jones, 2022). Seals at the New York Aquarium have a history of receiving novel environmental enrichment devices, and have also been exposed to wooden platforms used as steps into holding pools. The population had not been exposed to larger floats in the exhibit until the installation of the novel float presented for this research. However, like other enrichment, as the novelty wears off over time, the float may be utilized less frequently.

While this analysis did not include the individual seals that hauled-out in each location, consistent footage revealed dominant male "Will" as the first to haul-out on the float solitarily and sometimes joined later by female "Sydney." Occasionally, seals "Murphy" or "Conway" would also join them. Seals "Coral," "Luna" and "Kordelia" were never seen using the float. In the wild, mature males are less likely to end a haul-out event than mature females (Hamilton et al., 2014). Because "Will" was consistently hauled-out on the float, this could contribute to why the float was utilized for a longer duration than the exhibit. In addition, adult male

harbor seals are solitary and rarely interact with other seals except to mate (Barefield, 2012), which could explain "Will's" behavior of consistently hauling-out on the float away from the exhibit rock work and other seals. Finally, "Will" is the dominant male in the exhibit and his presence, especially during rut, may have deterred some of the younger non-sexually mature seals from using the float.

Figure 4: EGAD sign outside the Harbor Seal exhibit explaining the human-made float.

The number of seals that hauled-out on the float never exceeded three seals, while the number of seals hauled-out on the exhibit rock work never exceeded six seals. Ultimately, the haul-out location utilized by most of the collection was the exhibit rock work and statistical significance displayed preference for rock work as a haul-out option overall. While the float was rated to hold the weight of the entire collection, the surface area was limited and the exhibit rock work far exceeded the float in size. Oftentimes, wild seals will haul-out in locations where they are not touching and display threats to one another if they do come into contact (Barefield, 2012). This could contribute to why the number of seals, and as a result seal minutes, on the float remained far less than the seal minutes on exhibit.

While wild seals haul-out near each other, they do this to share predator vigilance and minimize risk while resting (Hamilton et al., 2014). In an aquarium setting, predators are not a threat or a determining factor to seal haul-out preference, giving seals the luxury to explore different haul-out options without fear. This could explain why wild seals at Almada Point did not utilize the new haul-out until the original was destroyed, and why resident harbor seals at the New York Aquarium explored and used the new haul-out right away.

Lastly, the total amount of time and number of seals hauled-out increased in the second dataset compared to the first dataset. The percentage was chosen as a variable to solve for the differing number of seals in each dataset. The first dataset between April and May had overall less haul-out time and total number of seals than the second dataset between July and October (Table 2 and Table 3). The increased amount of haul-out time and number of seals in the second dataset could be due to time of year. Overall, longer durations of haul-out time happen during pupping, nursing and molting periods with haul-out time increasing from seven hours on average to 12 hours during these periods (Barefield, 2012). These three behaviors occurred only during the second dataset observations.

Research indicates harbor seals have favorite haul-out sites that they return to regularly in the wild (Barefield, 2012). When given the option of an additional float, at least one seal (typically "Will," "Sydney," "Murphy" or "Conway") utilized the float during the 24-hour time frame 100% of the nights. This indicates that seals can be behaviorally flexible when presented with additional haul-out choices in a controlled setting, and even demonstrate preference for a human-made float over exhibit rock work.

RESEARCH LIMITATIONS

There are a fair number of limitations and constraints when conducting research in an aquarium setting that should be identified. The New York Aquarium's Harbor Seal exhibit was limited by space, resources and sample sizes. Most importantly, the ratio of deck space on the human-made float only allowed a limited number of seals to utilize at a time. Wild seal populations opportunistically forage for prey in coastal waters (Hamilton et al., 2014) but the resident population at the New York Aquarium have three to four scheduled feeding times between 09:30 and 15:30 each day. Because harbor seals were fed on a routine schedule during the day and did not opportunistically hunt for food sources, haul-out time may have altered this setting. Furthermore, tidal patterns in the wild would change the time of day and duration of haul-out time for wild seals, whereas tidal patterns are not a factor in determining haul-out patterns in a controlled environment like the New York Aquarium.

EXPANDING ON RESEARCH

Building on this haul-out research, it would be interesting to study harbor seal behavioral flexibility in a controlled environment with additional measures. The first would be conducting the same research in one year's time, when the float is no longer novel to the resident seals. Research could also be conducted with an additional float, large enough to allow all seals adequate haul-out space. Collecting data on all individual's haul-out preferences would also expand on the initial research. Lastly, changing sample size or sex of the seals in the collection could broaden this research.

Haul-out behavior with the addition of a human-made float in a non-controlled

environment will reveal how seal behavior may change without the above-mentioned constraints of a controlled setting. Studying wild seal populations' behavioral flexibility when given an additional human-made haul-out would provide better insight into how the addition of predator risk, obtaining food sources and tidal patterns would affect wild seals' haul-out preferences. Unlike wild seals which haul-out closely together as a way to protect themselves from predation (Hamilton et al., 2014), captive harbor seals do not have natural predators in an aquarium environment and can haul-out in locations separate from each other without additional risk. Therefore, seals will haul-out in all available locations around the exhibit because risk of predation is omitted. These factors are important in determining behavioral flexibility and haul-out duration and location but were unfortunately unable to be measured in a controlled aquarium setting.

CONCLUSION

Zoos and aquariums interconnect science, policy, and education, and thus can actively participate in important conservation during the current critical era of environmental change. On a daily basis, zoos and aquariums collect observational data on their species to better understand the animals, monitor behavior and make suggestions to the care provided. Studying specific behaviors in captive animals can be a good first step in learning more about how wild counterparts might behave if given the same or similar circumstances. Observational research and conservation for any local species through ambassador animals can be demonstrated through similar studies across all zoos and aquariums.

An important step in advocacy one can act upon is highlighting critical steps towards protection of harbor seals on overcrowded beaches. Research conducted in a public setting like the New York Aquarium promotes education and protection for the wild harbor seal populations. Observational research can be used as an important conservation and education tool when done alongside the public. The Wildlife Conservation Society's Exhibition and Graphics Arts Department (EGAD) created an educational sign explaining the reasoning for the float on exhibit (Figure 4). The New York Aquarium's Social Media Team also highlighted the importance of this study in a post on the New York Aquarium's Instagram page. Combined with signage and informational social media posts, the human-made haul-out provides guests local to the area with educational information about conservation for the growing population of seals in urban areas like New York City. What's more, it can foster opportunities for visitor research, contributing to their understanding of local human-wildlife conflict and what actions should occur going forward.

Observational research conducted in a controlled environment is the first step in predicting alternative haul-out's conservation value for wild harbor seals. The results of this research suggest that harbor seals will likely accept both human-made and natural environments as haul-outs when given an option. Having novel human-made haul-outs could solve some of the human-wildlife conflicts on overcrowded and urban beaches by enticing even a proportion of the seals from beaches to utilize alternative haul-outs. As harbor seals continue to haul-out on overcrowded beaches, it is critical that beachgoers understand how important these essential resting locations are for the population. Advocating for the conservation of harbor seals and protection of their haul-outs is critical while alternative haul-outs are being researched.

Zoos and aquariums interconnect science, policy, and education, and thus can actively participate in important conservation during the current critical era of environmental change.

LITERATURE CITED

Allbrook, D., and Lopez, V. 2012. Disturbances to wild Harbour seals (Phoca vitulina) during the birthing season in the Dollard estuary, The Netherlands. https://www.leniethart.nl/wordpress/wp-content/uploads/2019/01/07-2012-Allbrook-Bernabeu-Lopez-Disturbances-to-wild-Harbour-seals-during-the-birthing-season-in-the-Dollard-estuary.compressed.pdf

Andersen, S.M. 2011. Harbour seals and human interactions in Danish waters. [Doctoral Dissertation, University of Southern Denmark and Department of Bioscience, Aarhus University, Denmark.]

Bangert, R. 2017. Harbor seals love their new float at Alameda Point. Sierra Club San Francisco Bay. https://www.sierraclub.org/san-francisco-bay/blog/2017/01/harbor-seals-love-their-new-float-alameda-point

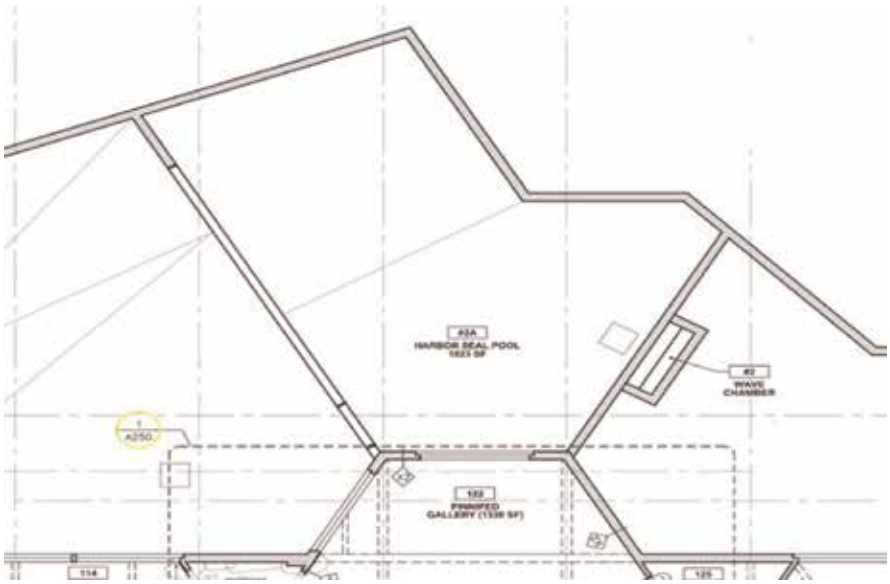


Figure A1: Blueprint of Harbor Seal exhibit at the New York Aquarium.

Figure A2: Google Map image of Harbor Seal exhibit at the New York Aquarium with labeled deck space areas.

Banton-Jones, K. 2022. How to Come up with and Implement Novel Enrichment Ideas. Wild Enrichment. https://wildenrichment.com/articles/how-to-come-up-with-and-implement-novel-enrichment-ideas/

Barefield, R. 2012. Eastern Pacific Harbor Seal Phoca vitulina richardii. https://munseysbearcamp.com/Harborseal.html

Blanchet,M.-A., Vincent, C., Womble, J.N., Steingass, S. M., and Desportes, G. 2021. Harbour Seals: Population Structure, Status, and Threats in a Rapidly Changing Environment. Oceans, 2:41–63. https://doi.org/10.3390/ oceans2010003

Bratton R., Jackman, J., Wood S., Dowling-Guyer, S., Vaske J., Bogomolni, A., Winton, M., Sanderson, M., Nichols, O., and Sette, L. 2023. Conflict with rebounding populations of marine predators: Management preferences of three stakeholder groups on Cape Cod, Massachusetts. Ocean and Coastal Management. No. 244: 1-11. https://doi.org/10.1016/j.ocecoaman.2023.106800.

Dwight, R., Brinks, M., Sharavana Kumar, G., and Semenza J. 2007. Beach Attendance and Bathing Rates for Southern California Beaches. Ocean & Coastal Management, Vol. 50. No. 10: 847-858. https://doi.org/10.1016/j.ocecoaman.2007.04.002.

Gili, C., Meijer, G., and Lacave, G. 2018. EAZA Marine Mammal TAG. Best Practices and Guidelines for Otariidae and Phocidae. 1-106. https://www.eaza.net/assets/Uploads/CCC/EAZA-EAAM-PinnipedGuidelines-approved.pdf

Hamilton, C., Lydersen, C., Ims R.A., and Kovacs, K.M. 2014. Haul-Out Behaviour of the World's Northernmost Population of Harbour Seals (Phoca vitulina) throughout the Year. https://doi.org/10.1371/journal.pone.0086055

Härkönen, T., Hårding, K.C. and Lunneryd, S.G. 1999. Age- and sex-specific behaviour in harbour seals Phoca vitulina leads to biased estimates of vital population parameters. Journal of Applied Ecology, No. 36: 825-841. https://doi.org/10.1046/j.1365-2664.1999.00434.x

Harvey, J.T., Chudzinska, M., McConnell, B., and Hastie, G. 2022. The Harbor Seal: The Most Ubiquitous Phocid in the Northern Hemisphere. Ethology and Behavioral Ecology of Phocids. Ethology and Behavioral Ecology of Marine Mammals. https://doi.org/10.1007/978-3-030-88923-4_10

Hubbert, J. 2022. Figure 1: Top view of float structure for New York Aquarium Harbor Seal exhibit and Figure 2: Side view of float structure for New York Aquarium Harbor Seal exhibit.

Image: Harbor seal distribution. Adapted by Nina Lisowski from Jefferson, T.A., Webber, M.A., and Pitman, R.L. 2015. In Marine Mammals of the World: A Comprehensive Guide to Their Identification, 2nd ed. Elsevier, San Diego.

Jansen, J., Boveng, P., Ver Hoef, J., Dahle, S., and Bengtson J. 2014. Natural and human effects on harbor seal abundance and spatial distribution in an Alaskan glacial fjord. Marine Mammal Science. https://doi.org/10.1111/mms.12140

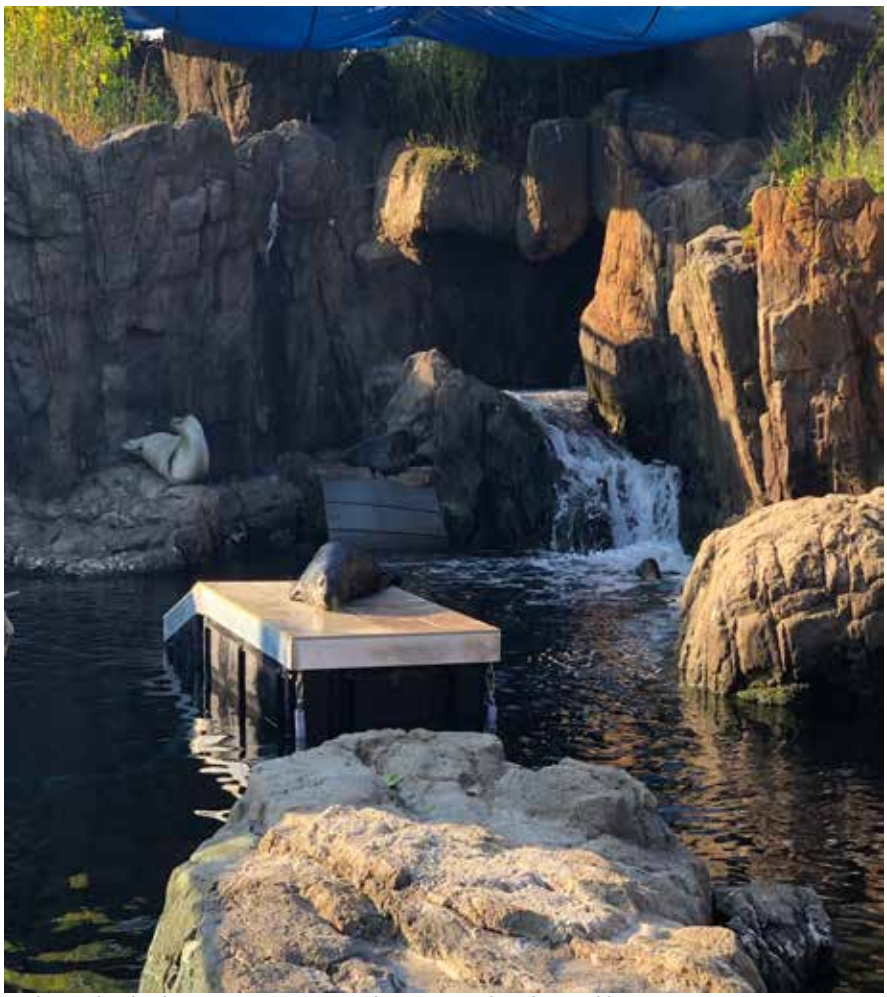
Jordan, J. 2017. Almada Point Harbor Seals Thriving on a New Dock. Wildlife. https://baynature.org/article/alameda-point-harbor-seals-thriving-new-dock/

Kienle, S.E. 2019. Intraspecific variation and behavioral flexibility in the foraging strategies of seals. [Doctoral Dissertation, UC Santa Cruz] https://escholarship.org/uc/item/0c69834b

Konrad, L., and Levine, A. 2021. Controversy over beach access restrictions at an urban coastal seal rookery: Exploring the drivers of conflict escalation and endurance at Children's Pool Beach in La Jolla, CA. Marine Policy Vol. 132. https://doi.org/10.1016/j.marpol.2021.104659.

Lea, S.E.G., Chow, P.K.Y., and Leaver, L.A. 2020. Behavioral flexibility: A review, a model, and some exploratory tests. Learn Behav Vol. 48, 173–187 https://doi.org/10.3758/s13420-020-00421-w

London JM, Ver Hoef JM, Jeffries SJ, Lance MM, and Boveng PL 2012. Haul-Out Behavior of Harbor Seals (Phoca vitulina) in Hood Canal, Washington. PLoS ONE Vol. 7, No. 6: 1-15. https://doi.org/10.1371/journal.pone.0038180



Harbor seal on haul-out structure at New York Aquarium. Photo by P. Hubbert

Lippsett, L. 2013. The Return of the Seals: Growing Herds Raise Questions of Sharks, Fish and Poop. Oceanus- Woods Hole Oceanographic Institute. https://www.whoi.edu/oceanus/feature/the-return-of-the-seals/?id=179209

Meade, T. M., Hutchinson, E., Krall, C., and Watson, J. 2014. Use of an Aquarium as a Novel Enrichment Item for Singly Housed Rhesus Macaques (Macaca mulatta). Journal of the American Association for Laboratory Animal Science Vol. 53, No. 5: 472–477. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4181688/

National Oceanic and Atmospheric Administration Fisheries. 2023. Species Directory: Harbor Seal. https://www.fisheries.noaa.gov/species/harbor-seal

Roman, J., Altman, I., Dunphy-Daly, M., Campbell, C., Jasny, M., and Read, A. 2013. The Marine Mammal Protection Act at 40: status, recovery and future of US marine mammals. Analysis of the New York Academy of Sciences. 29-49. https://www.uvm.edu/giee/pubpdfs/Roman_2013_Annals_of_the_NYAS.pdf

Wilson, S. 2017. The impact of human disturbance at seal haul-outs; A literature review for the Seal Conservation Society. Tara Seal Research. 1-43. https://www.pinnipeds.org/attachments/article/199/Disturbance%20for%20SCS%20-%20text.pdf

Zidar, J., Balogh, A., Leimar, O., and Løvlie, H. 2019. Generalization of learned preferences covaries with behavioral flexibility in red junglefowl chicks, Behavioral Ecology, Vol. 30, No. 5: 1375–1381. https://doi.org/10.1093/beheco/arz088

APPENDIX A: EXHIBIT DETAILS

The exhibit is filled with natural seawater originating from a pumping station that draws water from the Atlantic Ocean through a pipeline extending 183 meters southeast of the beach in front of the New York Aquarium. The exhibit has a chiller system that cools the water in the warmer months, usually keeping the temperatures between 45-65 degrees Fahrenheit year-round and always below the thermal maximum of 78 degrees Fahrenheit according to guidelines provided by the European Association of Zoos and Aquariums (Gili et al., 2018). The exhibit has one underwater viewing window and three public viewing windows. The exhibit haul-out areas include two beaches (Figure A2, areas “2” and “4”), one island (Figure A2, area “3”) and one entranceway (See area ‘1’ on Figure A2). The exhibit contains artificial rock work made of textured concrete and a ramp made of fiberglass.

APPENDIX B: CAPTIVE SEAL DEMOGRAPHICS

The harbor seal population included 1.5.0 seals for the first dataset and 1.6.0 seals for the second dataset. William is a Pacific male harbor seal born in captivity at SeaWorld San Diego in 2009. Coral is an Atlantic harbor seal born in captivity at Long Island Aquarium in 2007. Kordelia is a Pacific female harbor seal born in captivity at Alaska Sea Life Center in 2011. Sydney is a Pacific female harbor seal born in the wild in California 2020. Murphy is a female Atlantic harbor seal born in captivity at the New York Aquarium in 2020 (dam Coral). Luna is a female Pacific harbor seal born in captivity at the New York Aquarium in 2021 (dam Kordelia sire William). Conway is a Female half-Atlantic, half-Pacific harbor seal born in captivity at the New York Aquarium in 2022 in between the first and second dataset (dam Coral sire William).

The Journal of the American Association of Zoo Keepers, Inc.

Animal Keepers' Forum

June 2024, Volume 51, No. 6